COE 202- Digital Logic

Introduction

Dr. Abdulaziz Y. Barnawi

COE Department

KFUPM

Objectives

- Digital Systems
- “Analog” versus “Digital” parameters and systems
- Digitization of “Analog” signals
- Digital representation of information
- Effect of noise on the reliability and choice of digital system representation

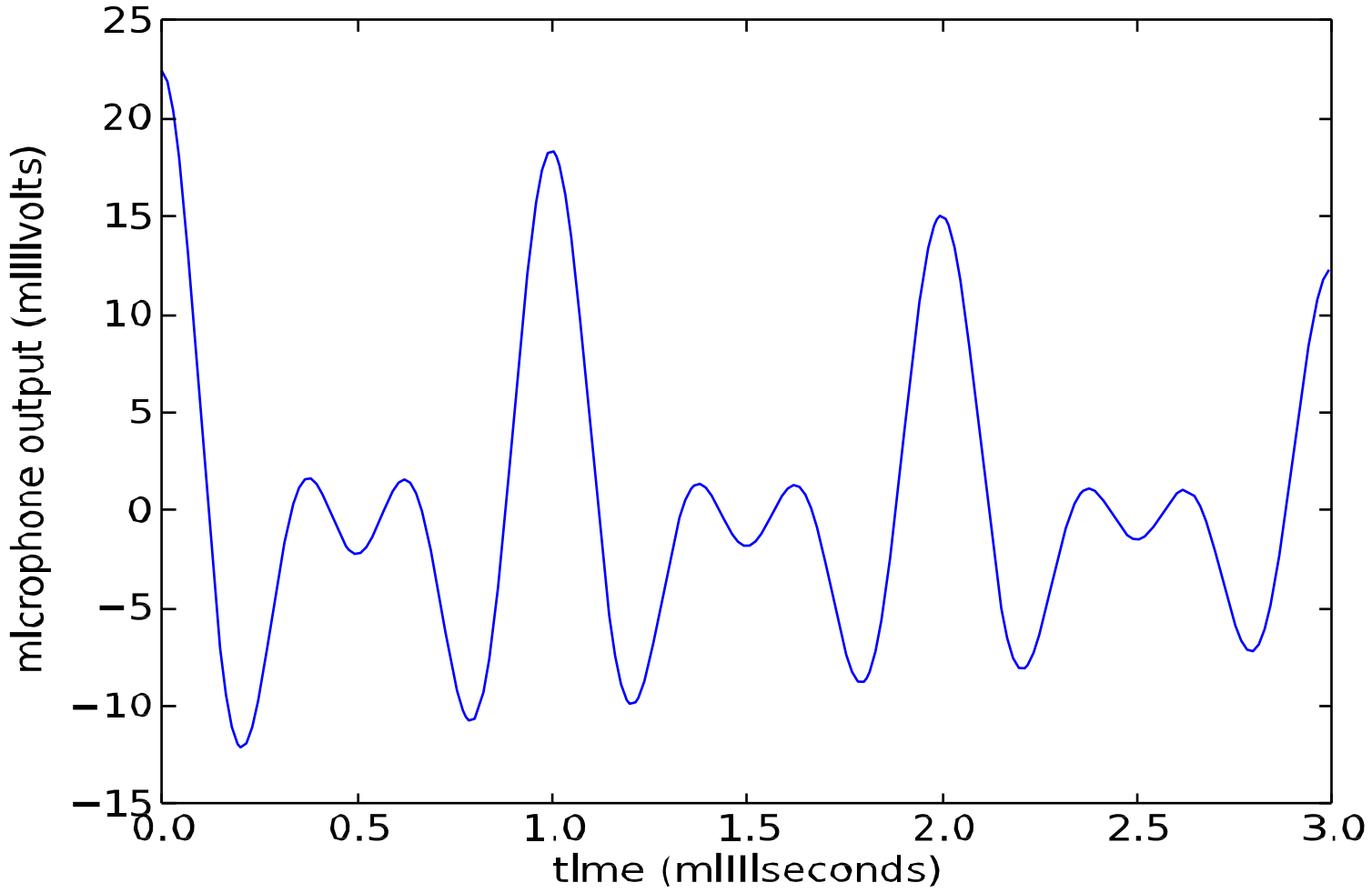
Digital Systems

- Digital Systems exist everywhere
  - Communication, banks, hospitals, Internet, automobiles etc.
  - Computers are digital systems
- Programmable, flexible

Digital vs. Analog Systems

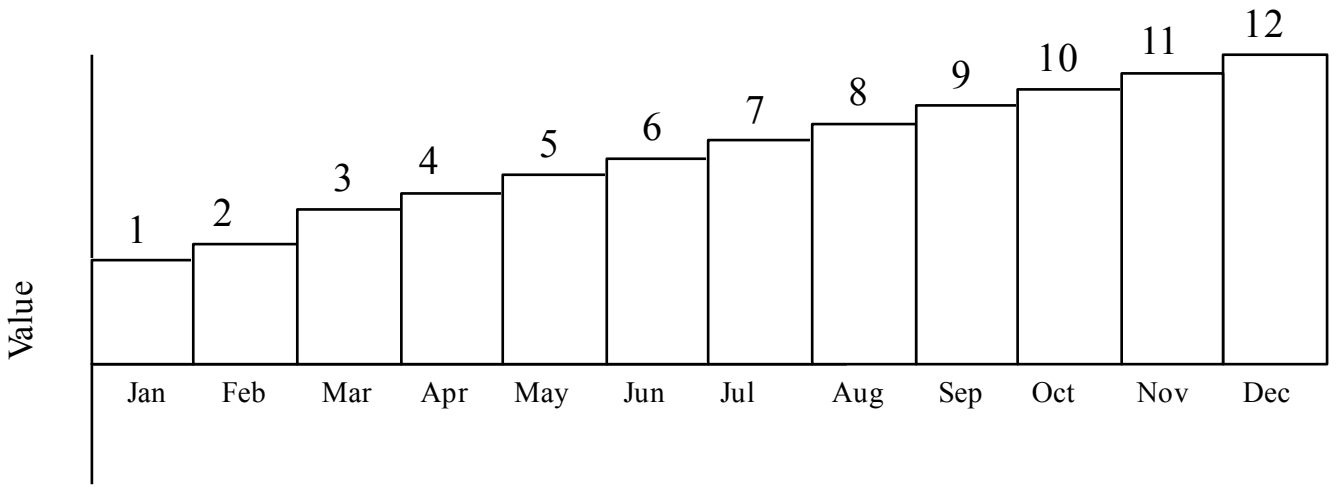
- We live in an analog world (continuous)
- Analog signals are continuous in nature
  - Smooth transition over a period of time or space
  - Represent a physical quantity or phenomenon
  - E.g. an output of a microphone: the voltage varies as a function of time.

Digital vs. Analog Systems



Digital vs. Analog Systems

- Digital signals are non-continuous i.e. discrete
  - Consist of fixed set of digits. E.g. number of months in a year = 12; digits = {1,2,3,….,10,11,12} note that 11.3 or 4.9 are invalid here.
  - Abrupt transition (jumping) from one digit to another



Digital vs. Analog Systems

- Digital or Analog?
  - Earth movement
  - English letters
  - Internet IP addresses
  - Human voice
  - Week days

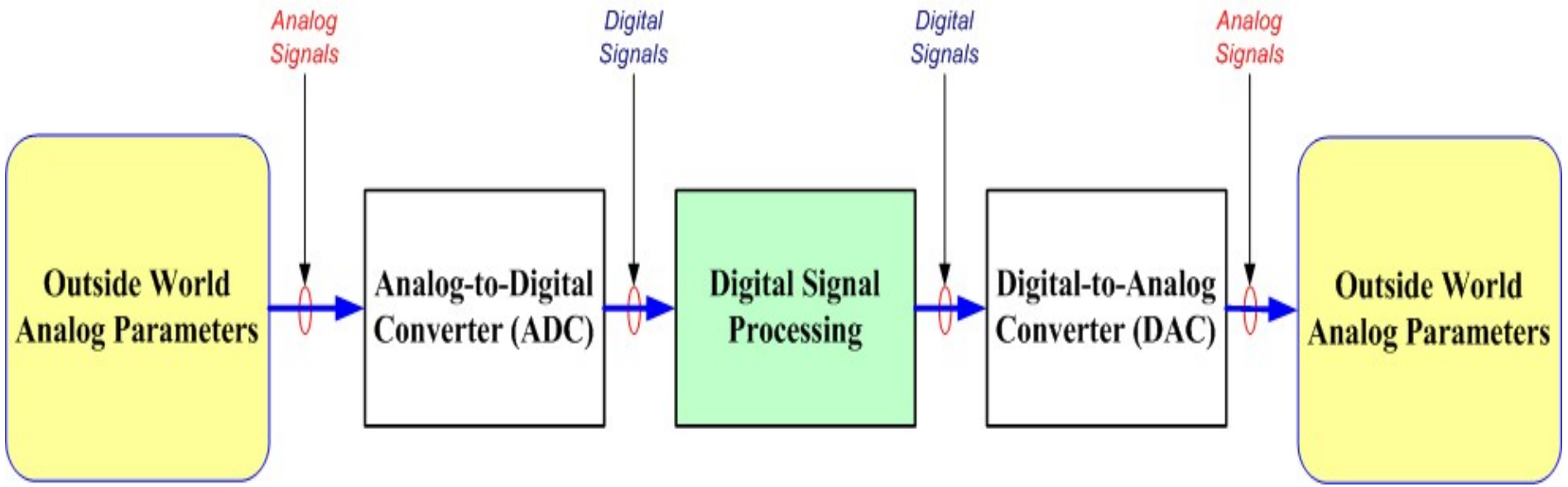
Digitization

- Process of conversion from analog to digital is called *digitization*
- Analog to digital (ADC) converters perform digitization
- Digital to analog (DAC) converters regenerate the analog signals from their digitized form

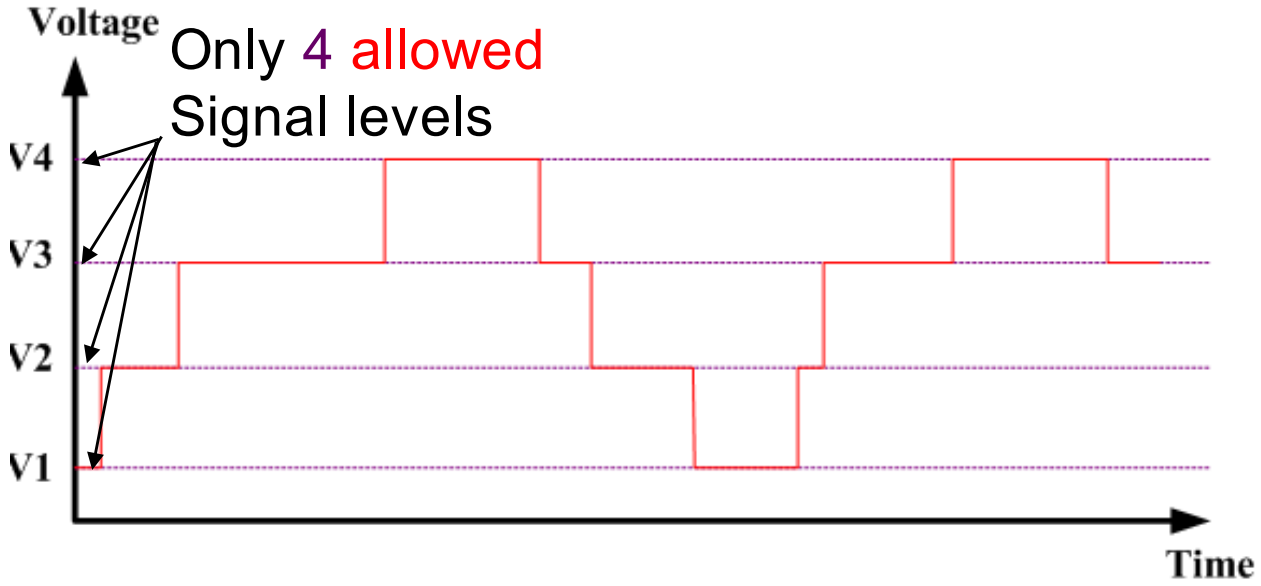
Digitization (Why?)

- The world around us is analog
- Digital systems are simple to understand & comprehend
- Thus …. Common practice is to convert analog signals into digital form for efficient processing of signals
- Inevitable to avoid loss of some accuracy (information) due to this conversion
- Reason: digital systems can only represent fixed (finite or discrete) set of values

Analog to Digital to Analog

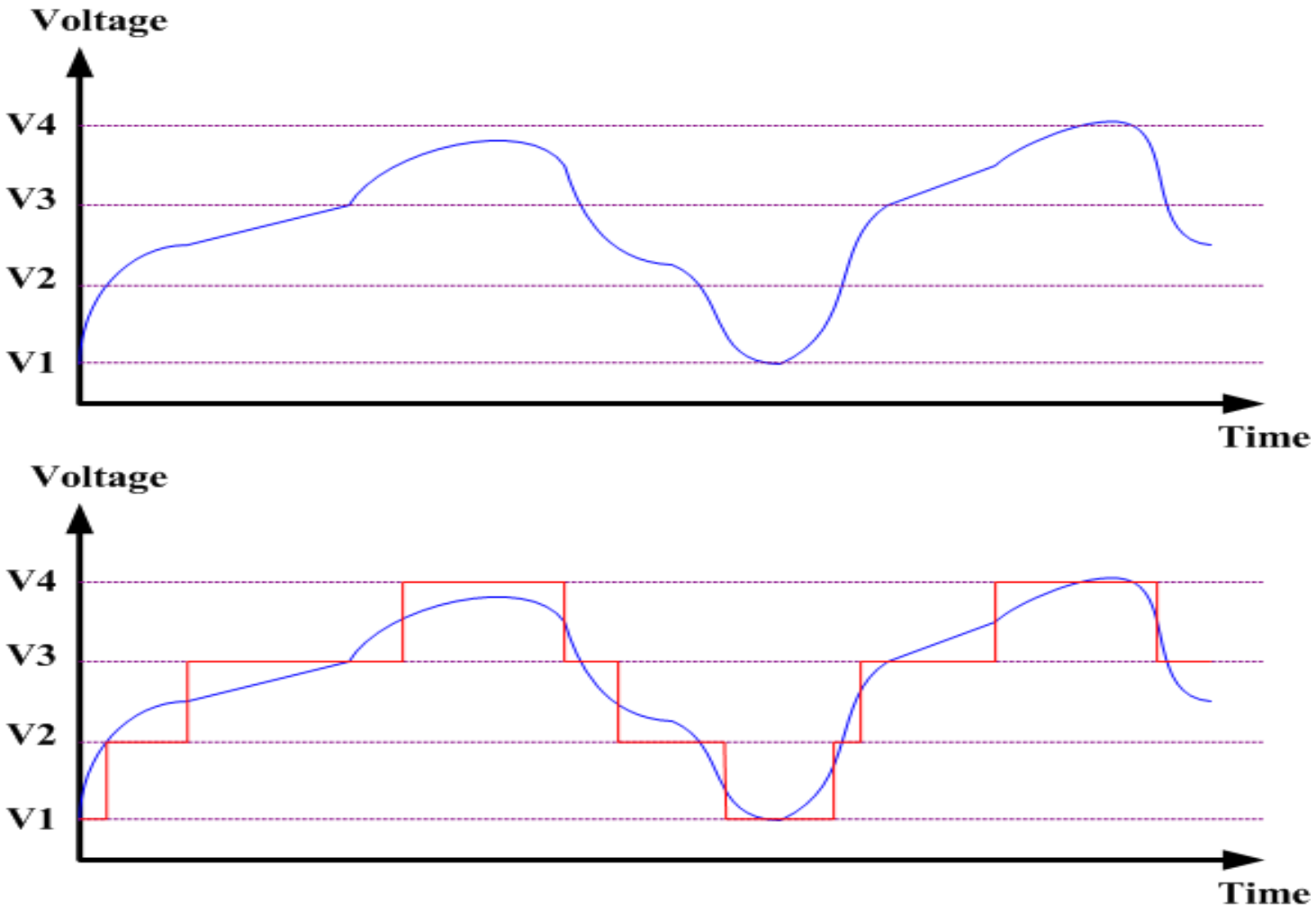


Digitization Example



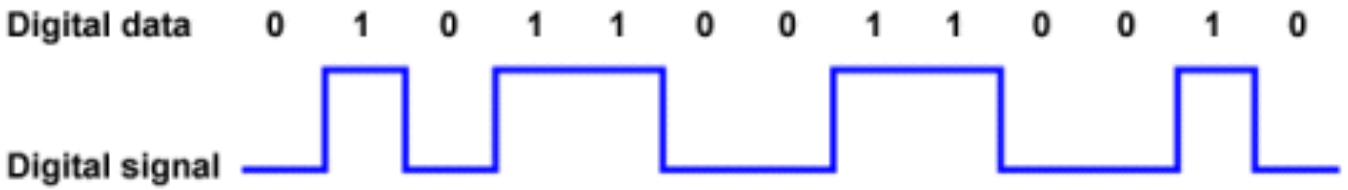
- The digital signal can contain a combination of only one of four voltage values – V1, V2, V3, V4
- Analog values are mapped to the closest allowed discrete voltage value, i.e. V1, V2, V3, V4

Digitization Example



Computers

- Computers are digital systems
- Deal with a vocabulary of two elements namely 0 and 1 – also known as the binary system of numbers
- Binary digits i.e. 0 and 1 are called bits
- Decimal digits 0,1,2,3,….,9 are simply called "digits" – these digits constitute the decimal number system



Data Representation

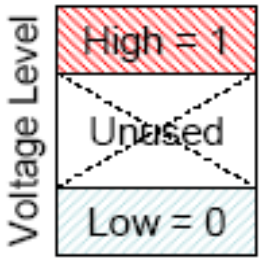
- Computers represent data (V1, V2, V3, V4) in binary system using:
  - Electrical voltages (processors, memory)
  - Magnetism (hard disks, floppy)
  - Light (CD, DVD)

Signal representation (Voltage)

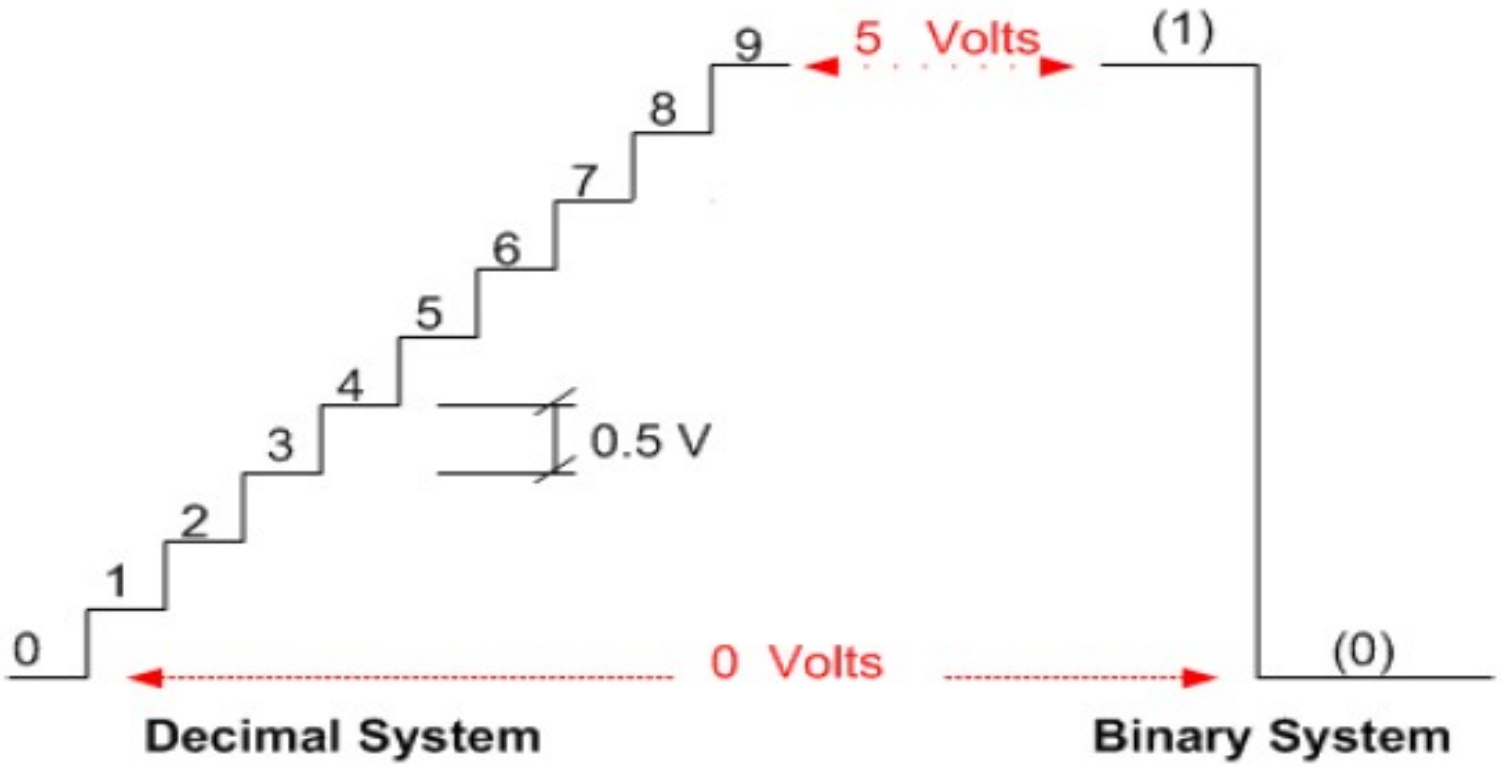
- Computers use low power supply voltage, typically from 0V to 5V
- In decimal numbering system, the voltage levels are divided into 10 equal parts. Therefore:
  - 0 represents 0 – 0.5V
  - 1 represents 0.5 – 1.0V
  - 2 represents 1.0-1.5V and so forth.
- Only 0.5V separate two consecutive voltage ranges if decimal digits are used.

Signal representation (Voltage)

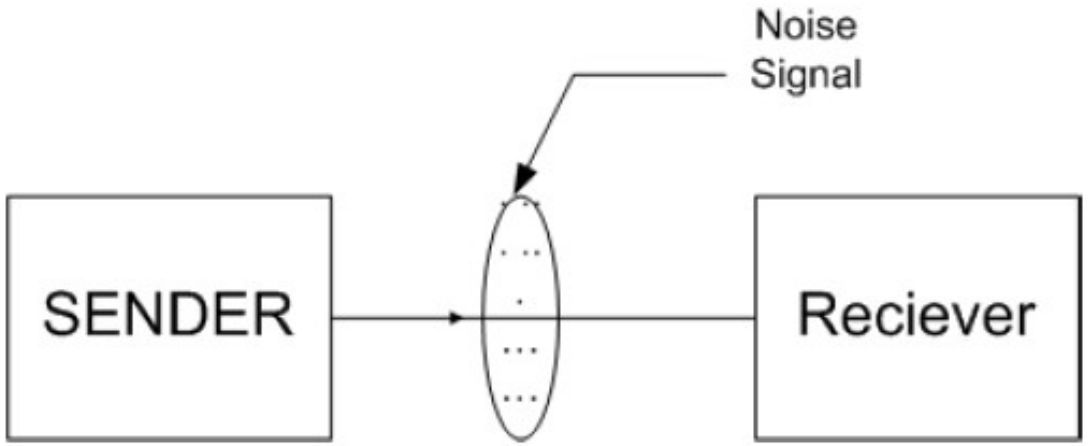
- Using the binary system, as is the case with all computers, and a low power voltage range from 0-5V
- A binary “0” is represented with 0 Volts
- A binary ”1” is represented with 5 Volts
- A larger range of Volts differentiate between the two values (0 and 1) in the binary system



Signal representation (Voltage)



Noise



- Noise exists in environments (mobile & TV)
- Noise can change voltage level (higher or lower)

Noise

- Noise exists in the environment
- It causes disruption in the voltage levels
- Noise margin calculations:
  - Let us assume that we need to choose n values in the range 0 to maximum value
  - Then compute step as = maximum value/n-1, i.e. 5/3 when n = 4, maximum value = 5
  - Compute maximum noise margin as = step/2 = 5/6 = 0.833
- If the range of differentiation between consecutive values is low, the data can be disrupted
  - Example: 1.6V (represented using decimal digit 3) when transmitted in a noisy environment becomes 1.5V (i.e. decimal digit 2), thus corrupting the data

Noise

Direct 10-level Representation

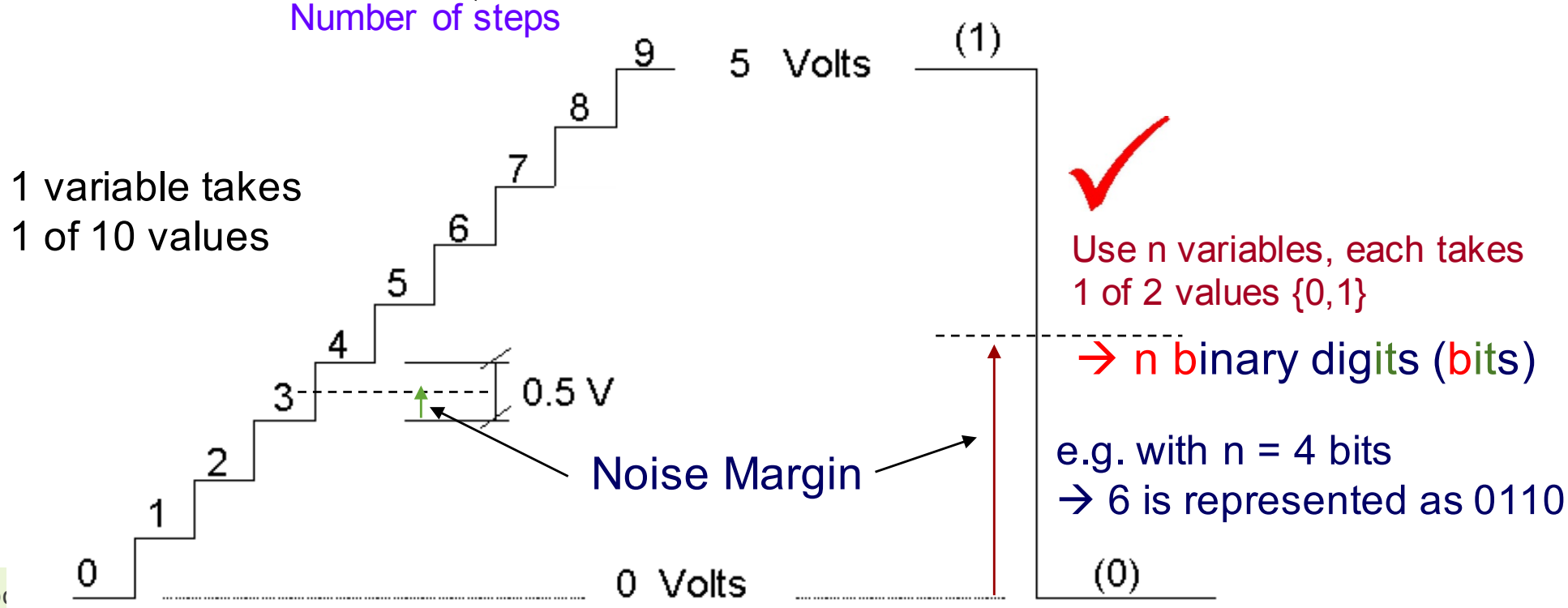
Using Binary (2-level) Representation

- Our circuits deal with: Ten Signal levels

  Two Signal levels (ON/OFF)
  Simpler, reliable Circuits

- Noise Margin: (5/9)/2 ≈ 0.25 V

  (5/1)/2 = 2.5 V
  Larger (better)



Noise

- The Larger the gap between voltage levels, the more reliable the system is. Thus, a signal representing a binary digit will be transmitted more reliably compared to a signal which represents a decimal digit.
- Good designs should guard against noisy environments to prevent misinterpretation of the signal information

Conclusions

- Information can be represented using analog and digital form
- Processing of digital data is flexible, reliable, simple and powerful
- Computers represent data using the binary system
- Digitization of data (converting from analog to digital)
- Next Lecture: Numbering systems (representation and manipulation)